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THE PROTECTION AGAINST MUSTARD GAS VAPOUR IN THE CHAMBER AFFORDED
BY A.V. IMPREGNATED KHAKI DRILL SHIRTS AND TROUSERS

SUMMARY

1. Trials have been carried out, with observers, to determine the protection against dosages up to 500 mg.min/cu.cm. of H (time 25 min.) under conditions of high temperatures (100 F.) and high humidity (85 per cent) of:

- (a) Ordnance issue K.D. shirts and trousers impregnated with A.V. but otherwise unmodified.
- (b) Ordnance issue K.D. shirts and trousers impregnated with A.V. and modified by the addition of A.V. impregnated flaps at the wrist and neck openings of the shirts and at the flaps of the trousers.

2. It is concluded that under the conditions of the trials K.D. trousers, A.V. impregnated, but otherwise unmodified, afford adequate protection when worn with anklets providing that the fly opening fits snugly. With unmodified K.D. shirts leakages at the wrists and neck openings cause vapour burns on the forearm and chest. Such leakages can be overcome by the provision of A.V. impregnated flaps at those points.

3. During the course of the trials the development of erythema and crusted lesions on the scalp was noted. It is suggested that, pending the development of a really satisfactory ointment A/G, the provision of an impregnated hood should be considered.

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5. The main details of the procedure in each trial were identical.

6. In each of the three (3) trials, four (4) observers were exposed to a concentration of mustard gas vapour in an 11 cubic metre chamber.

7. In Trials A and B, they were dressed as follows; (see Plate 1):

K.D. shirts	-	A.V. impregnated.
K.D. Trousers	-	A.V. impregnated.
Trunks (panties)	-	A.V. impregnated.
Anklets, socks and boots	-	Non-impregnated.
Hoods (U.S.)	-	CO ₂ impregnated.
Respirators, general service, at the gas position.		
Ointment A.G. No. 5, applied to the hands and wrists.		

8. As controls in Trials A and B, two (2) observers wearing U.S. horribone twill coveralls (CO₂ impregnated) instead of K.D. shirts and trousers, but otherwise dressed the same as those described above, were exposed.

9. In Trial C, the following modifications in dress were made, (see Plate II):

Trunks (panties) were not worn.
Hoods (U.S.) were not worn.
Respirators, light type, were substituted for the general service type.
Ointment, A.G. No. 5, was applied to the neck and ears as well as to the hands and wrists.

10. In Trial C, three (3) observers wearing A.V. impregnated K.D. shirts and trousers, modified by flaps at the cuffs, front opening and fly, were included as controls (see Plates III, IV and V).

11. The chamber was heated by a number of electric heaters and the humidity increased by the injection of steam into the chamber.

12. In Trials A and B the observers entered the warmed chamber fifteen (15) minutes before the concentration of mustard gas vapour was put up. In Trial C the concentration of vapour had been put up prior to their entering the chamber. During the period of exposure (twenty-five to thirty minutes) they carried out physical exercises for a period of one to two minutes repeated every five (5) minutes.

13. After exposure they continued to wear their test clothing for a period of four (4) hours, the first hour of which was spent in a room warmed to a temperature of 99 - 101 F. with a relative humidity of 65 per cent.

14. The vapour was put up by dropping a measured quantity of mustard gas (99 per cent pure) on to a hot plate in the chamber. The air was mixed by electric fans.

15. Vapour sampling was carried out through injector-operated bubblers, two (2) in series (ten litres per minute flow rate). Duplicate samples were taken over ten (10) minute periods during the period of exposure of the observers.

16. Sampling times were as follows:

(a) Zero (Z)	to Z + 10 minutes.
(b) Z + 10 minutes	to Z + 20 minutes.
(c) Z + 20 minutes	to Z + 30 minutes.

17. Analyses were made by the iodoplatinate and bromine titration methods.

RESULTS

18. In summary, the results were as follows:

TRIAL	Conc. of Mustard Vapour (mgm./cu.m.)	Total Dose of Mustard Vapour (mgm.mil./cu.m.)	Exposure Time	Temperature in Chamber	Relative Humidity in Chamber	Results (Observation period: 6 days)
A	Z to Z + 10 min. 7.5-9.2 Z + 10 to Z + 20 min. 0.9-0.15 Z + 20 to Z + 30 min. 0.0-0.0	84 - 94	30 mins.	101° F.	87 per cent	4/4. No effect.
B	Z to Z + 10 min. 19.2 - 20.3 Z + 10 to Z + 20 min. 17.8 - 18.0 Z + 20 to Z + 30 min. 17.0 - 18.0	470 - 490	26 mins.	101° F.	83 per cent	4/4. Sharp erythema on outer aspect of forearms stretching from wrist to elbow. In 1/4, mild erythema on back. Controls wearing OC ₂ (U.S.) impregnated coveralls showed no effects.
C	Z to Z + 10 min. 20.7 - 18.8 Z + 10 to Z + 20 min. 15.1 - 13.4 Z + 20 to Z + 25 min. 16.7 - 12.5	440 - 380	25 mins.	103°F.	89 per cent	4/4. Erythema on forearms as in Trial B. Erythema on upper abdomen and lower chest from navel to angle of ribs. 3/4. Crusted lesions on scalp. Controls, wearing A.V. shirts and trousers modified by flaps showed no effects except crusted lesions on the scalp.

DISCUSSION

19. The results of these trials show that the A.V. impregnated K.D. shirt allows the entrance of mustard vapour through the slit above the cuff.

20. In Trials A and B no vapour effects were seen along the line of the front opening of the shirt, even though, in some cases, the buttons were badly placed and some puckering occurred when the buttons were fastened. This may have been due to the pressure of the respirator haversack on the front of the shirt forming an effective seal. In Trial C, when the general service respirator was replaced by the light type respirator, erythema developed on the upper abdomen and lower chest in all four (4) cases indicating a leakage along part of the frontal opening. Therefore, the impregnated K.D. shirt requires modification in design before it is made a general issue as an article of anti-gas equipment.

21. In Trials A and B impregnated hoods were worn. In Trial C the hoods were omitted and the exposed skin of the face and neck was protected with ointment A.G. No. 5. In those cases in which the collars fitted too loosely, a tape or tie was worn around the neck. No vapour lesion developed on the neck or upper part of the chest.

22. In Trial B one observer developed a mild erythema on the back, sharply limited above by the line of the impregnated hood. In this case, the cause of the leakage was not determined.

23. In Trial C impregnated trunks (pants) were not worn. No leakage occurred through the fly in any of the observers wearing either the unaltered or the modified trousers.

24. Apart from crusted lesions on the scalp, no vapour effects developed in the observers wearing the K.D. trousers and shirts modified by the inclusion of flaps at the cuffs, front opening and fly.

25. No toxic reactions attributable to the wearing of the A.V. impregnated clothing were detected in any of the observers.

26. The observations were made under severe conditions of temperature (101 - 103° F.) and relative humidity (83 - 89 per cent).

27. When in the chamber, and for one (1) hour afterwards, during which the men were kept in a warm room, the shirts of all observers were drenched with sweat. The trousers were all damp and in most cases, sweat had appeared through at the knees and thighs.

28. The trial garments used in Trials B and C have been submitted to C.W. Laboratories, Ottawa, for estimation of A.V. content.

SUMMARY AND CONCLUSIONS

29. Chamber trials have been carried out to determine the degree of protection against mustard gas vapour afforded by A.V. impregnated Khaki Drill (K.D.) shirts and trousers.

30. At OT's of 400 - 500 (T = 25 minutes), leakage of vapour occurred through the opening above the cuff resulting in vapour burns extending from the wrist to the elbow.

31. Vapour burns developed on the lower portion of the front of the chest due to leakage through the front opening of the shirt. When the general service respirator haversack was worn, this leakage did not occur.
32. These vapour burns on the arms and trunk did not occur when the shirt was modified by the inclusion of flaps at the cuffs and along the front opening.
33. A.V. impregnated K.D. trousers with a properly fitting fly and worn with anklets gave effective protection against OT's of 400 - 500.
34. When impregnated hoods were not worn, erythema and crusted lesions developed on the scalp.
35. These trials were carried out under conditions of high temperature (101 - 103°F.) and high relative humidity (83 - 89 per cent).

RECOMMENDATIONS

36. Laboratory and chamber tests should be made with khaki drill shirts and trousers impregnated with A.V. to determine the effect of profuse sweating on the impregnate content of the garments.
37. If these garments are otherwise acceptable, the shirt should be modified by the inclusion of flaps at the cuffs and at the front opening. If the cuffs and collar do not fit well, they should be fastened by tapes.
38. In the case of the K.D. trousers, providing the fly is reasonably well tailored and anklets are worn, no modification is necessary to protect against OT's as high as 500.
39. Some form of protection against mustard gas vapour for the scalp should be adopted for general issue with anti-gas equipment. Until an entirely satisfactory anti-gas ointment has been developed, which will protect the exposed portions of the face, ears and neck, the possible advantages of the impregnated hood should be reconsidered.

Note: The garments used in these trials were impregnated and supplied by the Chemical Warfare Laboratories, Ottawa, at whose request the trials were carried out.

These trials were carried out by Major W. Somerville, R.A.M.C., Surg. Lt. Cmdr. D.D. Bonnycastle, R.C.N.V.R., and F/L H.L. Dobson, R.C.A.F., of the Physiological Section. This report was prepared by Major W. Somerville.

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Plate No. 1 5.P.151.782.4
Observer wearing Khaki Drill shirt and trousers as in Trials A and B. The only lesions which developed were on the forearms. The respirator haversack forms an effective seal at the front opening of the shirt.

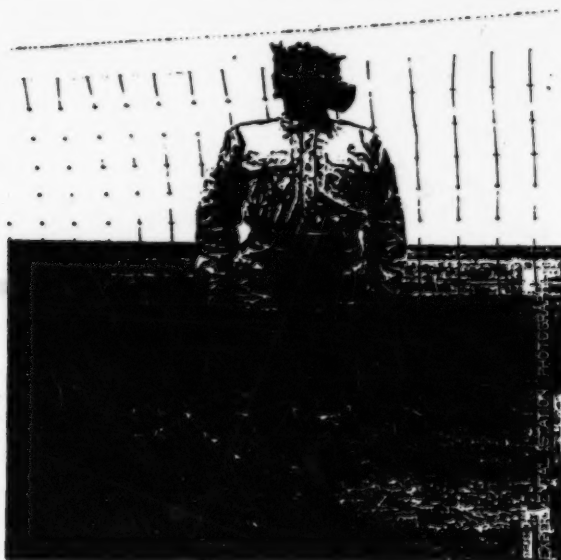


Plate No. 2 5.P.151-782.5
In Trial C, the light type respirator replaced the general service respirator. Without the haversack on the chest to form or act as a seal, vapour gained entrance through the front opening of the shirt. As a result, vapour burns developed on the chest and upper abdomen as well as on the forearms.
(See Plate 6)



Plate 3

5.P.151.782.1



Plate 4

5.P.151.782.3

Khaki Drill shirt, A.V. impregnated, showing flap which is sewn on to the left side of the front opening and buttons over to the right. The cuff flap is sewn on to both sides of the cuff opening. Shirts modified in this fashion, protected against a concentration of mustard gas vapour which produced burns on observers wearing unmodified shirts.

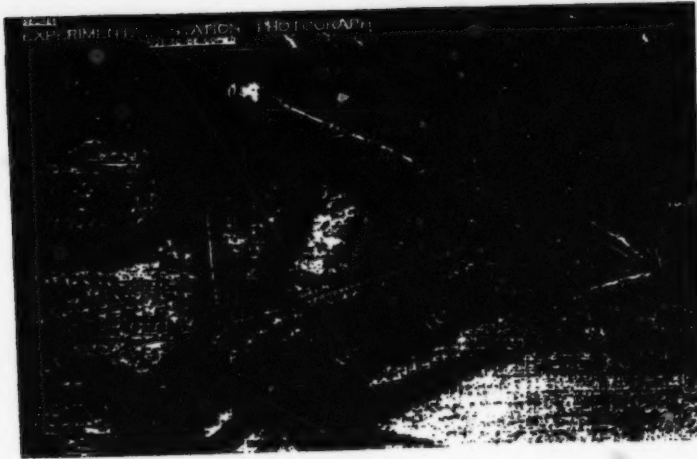


Plate 5/ 5.P.151.782.2
Khaki Drill trousers, A.V. impregnated, showing flap attached to the right side, buttoning over to the left. No vapour leakage occurred through the front openings of impregnated trousers with or without this modification.

Plate 6
(Colour Transparency) Observer seven days after exposure to Ct 400 (t:25 mins.) while wearing khaki drill shirt and trousers, A.V. impregnated. There is a vesication of the inner aspect of both forearms. Erythema limited below by the upper border of the impregnated trousers; involves the upper abdomen and chest front and back, shoulders and arms. Light type respirators were worn and the eyes and respiratory tract were unaffected.



